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PREDATOR–PREY RATIOS OF MACROINVERTEBRATES IN WHEAT AND SUGARCANE AGROECOSYSTEMS

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The present study on selected species of coleopteran, hymenopterans, arachnids and hemipterans was conducted to evaluate prey-predator ratios (p/p) based on the logistic abundance of species on wheat-weeds and sugarcane-weeds agro-ecosystems in Faisalabad District. Theoretically, these interactions have significant impact on the structure and dynamics of an agro-ecosystem. Polynomial regression was applied on the relative abundance of selected predators with each of the prey species. In wheat-weeds agro-ecosystem coleopterans and hymenopterans predators showed more $R^2 = 0.70$ with aphids and *P. perpusilla.* Whereas in sugarcane-weeds agro-ecosystem coleopterans, arachnids and only single species of hymenopterans showed more $R^2 = 0.70$ with aphids and *P. perpusilla*. By using such inferences species specific biological control can be applied against targeted pests of wheat-weeds and sugarcane-weeds agro-ecosystems.
Keywords: Biodiversity, Ecosystem, Community, Niche, Agriculture

INTRODUCTION

Communities are groups of various populations, which interact in space and time for satisfying their survival needs. A prime research focus to identify the different processes and mechanisms that control the dynamics of these interacting groups of populations in an ecosystem (Abbas *et al*., 2013a; Chattha *et al*., 2013). Western and Pearl (1989) estimated that natural ecosystems comprises approximately 5% of the total terrestrial environment in comparison to agriculture and commercial forestry, which covers almost 50% and 20% of terrestrial environment respectively.

In Pakistan wheat and sugarcane are considered most important crops, which are used to make different every day used products in kitchen (Ruby *et al*., 2011a; Quddus and Mustafa, 2011; Arshad, 2012). However rapid increase in population required for higher production of wheat and sugarcane to fulfill the needs of this growing population in Pakistan, resultantly transforming organic farming to intensive farming (Offermann and Nieberg, 2000; Prakash and Conko, 2004; Seufert *et al*., 2012). Intensive farming practices encourage increased production without examining its long term consequences, such as degradation of soil, contamination of groundwater by agro-chemicals and declining of biodiversity at all levels (Piper, 1999; Abbas *et al*., 2013a). Hence, researchers all over the globe are striving to conserve biodiversity as it stabilizes the balance among organisms of different functional groups (predator-prey) in an ecosystem (Moguel and Toledo 1999; Power and Flecker 2000).

Macro-invertebrate pests (arthropod pests) are one of the economically important factors responsible for decraese in quality and quantity of crop (Oerke and Dehne, 2004). For instance the dipterans, aphides, cicadas and thrips etc. are the main pest groups in wheat fields (Malschi, 2003), whereas top borer (*Scirpophaga nivella* F.), stem borer (*Chilo infuscatellus* Snell), root borer (*Emmalocera depressella* Swin.) and Gurdaspur borer (*Acigona steniellus* Hampson) are destructive pests in sugarcane fields (Ashraf and Fatima, 1980). The biological control is natural phenomena for regulation of pest species and their natural enemies in an ecosystem. It is self perpetuating, no adverse side effects on the environment and no risk for non-target organisms (Payne *et al*., 1993). It depends upon the natural predator, Coleopterans and arachnids predator species have potential value to decline the pests species in agro-ecosystems (jayakumar and Sankari, 2010; Inayat *et al.*, 2011).

The main objective of the present study was to evaluate prey-predator (p/p) relationship among slected macroinvertebrate species. Previously such studies are scarce on wheat-weeds and sugarcane-weeds agro-ecosyetms in Punjab, Pakistan (Inayat *et al.*, 2011; Abbas *et al*., 2012; Abbas *et al*., 2013a; Abbas *et al*., 2014).

MATERIALS AND METHODS

Coccinella septempunctata, Chilomenes sexmaculata, Coccinella trifasciata, Oxyopes sertatus, Oxyopes javanus, Camponotus spp., Solenopsis invicta and *Solenopsis xyloni* and their suspected preys *Pyrilla perpusilla, Dysdercus cingulatus, Acyrthosiphon gossypii, Schizaphus graminum Aphis nerii, Xyonysius californicus, Cavelerius saccharivorus* and *Perkinsiella saccharicida* were captured from wheat-weeds and sugarcane-weeds agro-ecosystems in Faisalabad district. The collection was made on weekly basis from both agro-ecosystems, in the periphery of Faisalabad District. Total 12 sampling sites were surveyed

for the collection in almost each direction. At each site a block of 2.02 hectare of both wheat-weeds and sugarcane-weeds were selected. The sweep net was used to collect foliage macroinvertebrates from these fields.

The captured macroinvertebrate groups were preserved in glass vials containing 70% ethanol, labeled with type of crop, date of collection etc and brought to laboratory for identification in the Department of Zoology and Fisheries, University of Agriculture Faisalabad. All these specimens were identified up to species level by consulting available literature and electronic keys available on internet, moreover these identified specimens were further confirmed comparing persevered specimens in the entomology museum, Department of Entomology, University Agriculture, Faisalabad, Pakistan.

The predator-prey abundance (p/p) ratio of predator with prey species was estimated by simply dividing the density of a predator with density of prey species in monthly sampling. The p/p abundance ratio of species in each crop also combined abundance of each species in all crops was plotted against time scale of monthly samples. The functional response of a predator is a key factor regulating the population dynamics of predator-prey systems. The functional response may represent an increasing linear relationship (type 1) that is a constant rate of prey killing to yield a density dependant, prey mortality the multi-coulered Asian coccinellid, Harmonia axyridis was reported to exhibit type I functional response on the aphids. This was depicted as a good association, meaning that predators built up when preys are in abundance and restricted the population of prey species to certain number. Simple linear regression test was applied to test the validity of the relationship.

Assumptions of predator-prey association: The predation efficiency depends on the cost-effective availability of its prey species. It also depends on the adaptive efficiency of the predator in approaching. Manipulating and utilizing the prey species. Quality and quantity of the prey species is also an important factor. An optimality and model favor specialist/ stenophagus predators and assures the availability of almost fixed number of prey in the area. Even for generalists there is some hierarchy of preferred food items and so is the adaptability of the individuals within the population of generalist predators.

RESULTS

Seven predator species belong to three taxon such as *Coccinella septempunctata*, *Coccinella trifasciata*, *Chilomenes sexmaculata* (Coleoptera) *Solenopsis invicta*, *Camponotus* spp., *Solenopsis xyloni* (Hymenoptera), *Oxyopes sertatus* and *Oxyopes javanus* (Archnida) and their seven suspected prey species of single taxon like *Xyonysius californicus*, *Cavelerius saccharivorus*, *Pyrilla perpusilla*, *Dysdercus cingulatus*, *Acyrthosiphon gossypii*, *Schizaphus graminum* and *Aphis nerii* (Hemiptera) were selected from foliage macro-invertebrate population of both wheat-weeds

Table 1: Coefficient of determination value (R^2) for some coleopterans, hymenopterans and arachnids predators with selected prey species in wheat and sugarcane

Predator	Prey	Crops	
		Wheat	Sugarcane
Coccinella septempunctata	*Xyonysius californicus*	-	0.529
	Cavelerius saccharivorus	-	0.416
	Pyrilla perpusilla	0.508	0.800
	Dysdercus cingulatus	0.583	-
	Acyrthosiphon gossypii	0.386	-
	Schizaphus graminum	0.713	-
	Aphis nerii	0.970	0.517
Coccinella trifasciata	*Xyonysius californicus*	-	0.437
	Cavelerius saccharivorus	-	0.505
	Pyrilla perpusilla	-	0.831
	Dysdercus cingulatus	-	-
	Acyrthosiphon gossypii	-	-
	Schizaphus graminum	-	-
	Aphis nerii	-	0.431
Chilomenes sexmaculata	*Xyonysius californicus*	-	-
	Cavelerius saccharivorus	-	-
	Pyrilla perpusilla	0.966	-
	Dysdercus cingulatus	0.446	-
	Acyrthosiphon gossypii	0.846	-
	Schizaphus graminum	0.672	-
	Aphis nerii	0.997	-
Solenopsis invicta	*Xyonysius californicus*	-	0.672
	Cavelerius saccharivorus	-	0.606
	Pyrilla perpusilla	-	0.257
	Dysdercus cingulatus	-	-
	Acyrthosiphon gossypii	-	-
	Schizaphus graminum	-	-
	Aphis nerii	-	0.811
Camponotus spp.	*Xyonysius californicus*	-	-
	Cavelerius saccharivorus	-	-
	Pyrilla perpusilla	0.908	-
	Dysdercus cingulatus	0.410	-
	Acyrthosiphon gossypii	0.794	-
	Schizaphus graminum	0.127	-
	Aphis nerii	0.653	-
Solenopsis xyloni	*Xyonysius californicus*	-	-
	Cavelerius saccharivorus	-	-
	Pyrilla perpusilla	0.171	-
	Dysdercus cingulatus	0.901	-
	Acyrthosiphon gossypii	0.162	-
	Schizaphus graminum	0.788	-
	Aphis nerii	0.407	-
	Xyonysius californicus	-	0.384
Oxyopes sertatus			
	Cavelerius saccharivorus	-	0.725
	Pyrilla perpusilla	-	0.202
	Dysdercus cingulatus	-	-
	Acyrthosiphon gossypii	-	-
	Schizaphus graminum	-	-
	Aphis nerii	-	0.477
Oxyopes javanus	*Xyonysius californicus*	-	0.957
	Cavelerius saccharivorus	-	0.192
	Pyrilla perpusilla	-	0.537
	Dysdercus cingulatus	-	-
	Acyrthosiphon gossypii	-	-
	Schizaphus graminum	-	-
	Aphis nerii	-	0.433

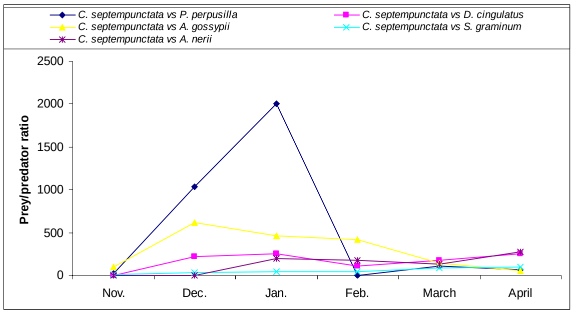

Figure 1: Extent of variation in the abundance ratio of *C. septumpunctata* with hemipterans species in wheat-weeds agroecosystem

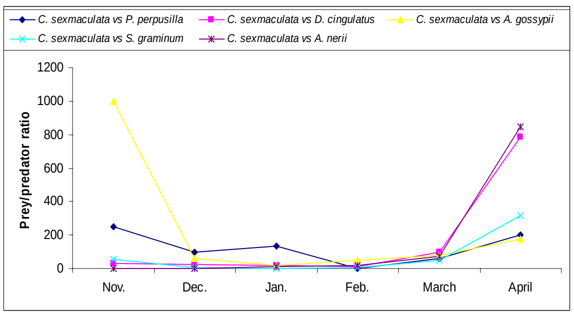

Figure 2: Extent of variation in the abundance ratio of *C. sexmaculata* with hemipterans species in wheat-weeds agroecosystem

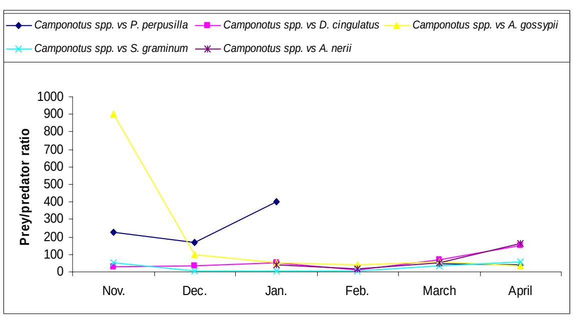

Figure 3: Extent of variation in the abundance ratio of *Camponotus* spp. with hemipterans species in wheat-weeds agroecosystem

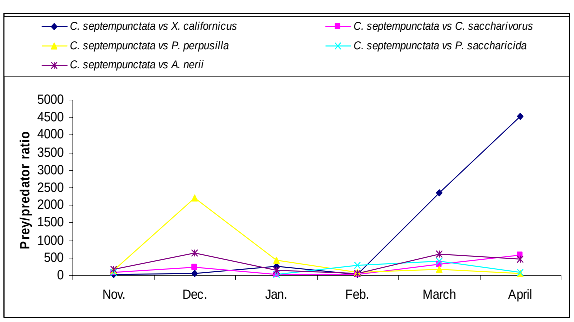

Figure 4: Extent of variation in the abundance ratio of *C. septumpunctata* with hemipterans species in sugarcane-weeds agroecosystem

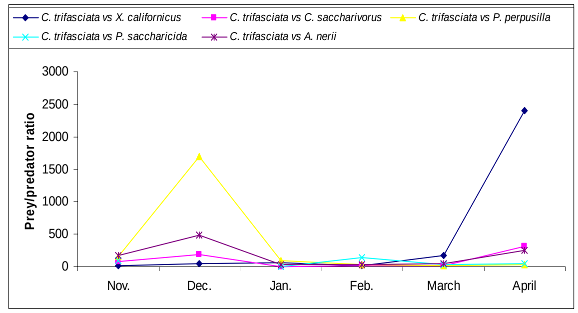

Figure 5: Extent of variation in the abundance ratio of *C. trifaciata* with hemipterans species in sugarcane-weeds agroecosystem

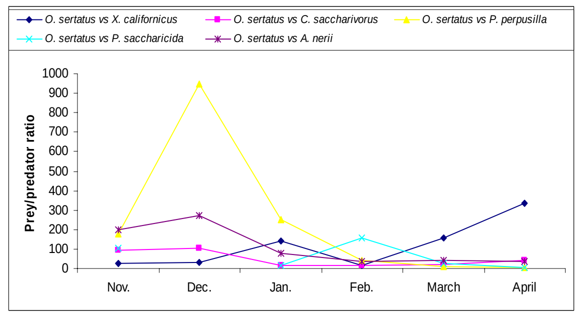

Figure 6: Extent of variation in the abundance ratio of *O. seratus* with hemipterans species in sugarcane-weeds agroecosystem

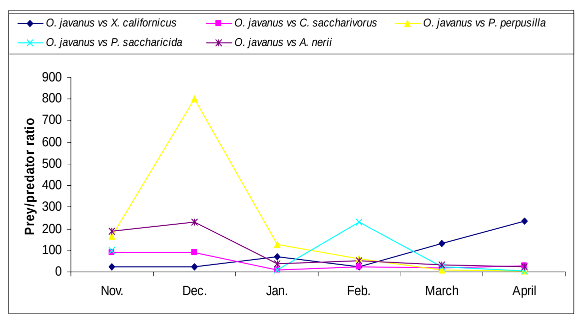

Figure 7: Extent of variation in the abundance ratio of *O. javanus* with hemipterans species in sugarcane-weeds agroecosystem

and sugarcane-weeds agro-ecosystems, selection of these predator and prey species were made on their monthly abundance to assess predator-prey relationship among these selected species.

Monthly predator-prey abundance ratio of each selected predator with all the hemipterans prey species are presented in Fig. 1-7. Constant or nearly constant predator-prey ratios appeared as straight line parallel to the time scale, for some of the predator species in wheat-weeds and sugarcane agro-ecosystems.

Predator-prey association in wheat: Polynomial regression analysis on the selected predator and prey species in wheat-weeds agro-ecosystem depicted that *S. graminum* (R^2 =

0.7139), *A. nerii* (R^2 = 0.9702) *P. perpusilla* (R^2 = 0.9661), *A. gosspii* (R^2 = 0.8462) and *A. nerii* (R^2 = 0.9971) were preferred prey for *C. septumpunctata* species (Fig. 4, 5, 6, 7, 8), respectively. Whereas *A. gosspii (*R^2 = 0.7941) was most preferred prey for *Camponotus* spp. (Table 1).

Predator-prey association in sugarcane: Polynomial regression analysis was applied to evaluate relationship among selected predator and prey species in sugarcane-weeds agro-ecosystem. *P. perpusilla* (R^2 = 0.8001) was the preferred prey species of *C. septumpunctata* (Fig. 14) as well as *P. perpusilla* (R^2 = 0.831) was also recorded as preferred prey species of *C. trifaciata* (Figure 6.15). *C. saccharivorus* (R^2 = 0.725) of *O. seratus* (Fig. 16), *X. californicus* (R^2 = 0.725) of *O. javanus* (Fig. 17) whereas *A. nerii* (R^2 = 0.812) was the preferred prey species of *S. invicta* (Table 1).

DISCUSSION

Health of an ecosystem depends upon balanced prey-predator ratios and the productivity of an agro-ecosystem is significantly relying on it. The balanced prey-predator ratios favors high and good quality yield. Assessment of prey-predator ratios from the selected macro-invertebrates groups in wheat-weeds and sugarcane-weeds agro-ecosystems were conducted in the present study. It is evident that Bart-lett's (1949) regression analysis method should be considered as the best choice for analyzing prey-predator ratios. The major problem with using simple ratios to evaluate prey-predator ratio is one of sampling bias due to variation in animal methodologies or behavior. Jeffries and Lawton (1985) documented that the variations in prey-predator ratios between studies may be partly due to different sampling intensities and Cameron (1972) reported that sampling may be significantly biased by the insects behavior (Fenton and Howell 1957).

Predator-prey models (about straight line through time scale) infer the rate of consumption as a behavioral phenomenon. According to classical hypothesis predators encounter prey randomly and the trophic function entirely depends on abundance of prey. The trophic function should be considered on the slow time scale of population dynamics at which the models operate. It is logical to suppose that the trophic function depends on the ratio of prey to abundances of predator (Arditi and Ginzburg, 1989).

Significant fluctuations were recorded in most of p/p ratios and this assumption was further confirmed by non-significant R-values derived from majority of regression analysis both in wheat-weeds and sugarcane-weeds agro-ecosystems. Species rich agroecosystem favours high p/p ratio (Jeifries and Lawton, 1985). The intensification by chemical and mechanical technologies in the agro-ecosystems is the more important factor for imbalance in p/p ratios (Inayat *et al.*, 2011; Ruby et al., 2011b; Abbas *et al*., 2013b). Siddiqui (2005) reported that the use of agrochemicals has been significantly increased in past few decades in such types of agro-ecosystems in Punjab, which inturn is responsible for change the frequency of predators, preys/pests and parasitoids species, ultimately decreasing crop yields.

CONCLUSION

The present study provides valuable information regarding p/p ratios in wheat-weeds and sugarcane-weeds agro-ecosystems to the farmers and enables them to develop strategies to cope with insect pests by introducing their natural enemies (predators) which in turn lead to enhance yield and sustain the food webs in such types of agro-ecosystems.

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